A New Flight Path at LANSCE for Fundamental Nuclear Physics and the NPDGamma Experiment

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APS April Meeting 2004
Denver, CO

NNSA — Los Alamos — Physics

Measurement of the Parity-Violating Gamma Asymmetry A_γ in the Capture of Polarized Cold Neutrons by Para-Hydrogen, $\vec{n} + p \rightarrow d + \gamma$

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Funded by: DOE (beamline), DOE/NSF/Institutions (experiment)

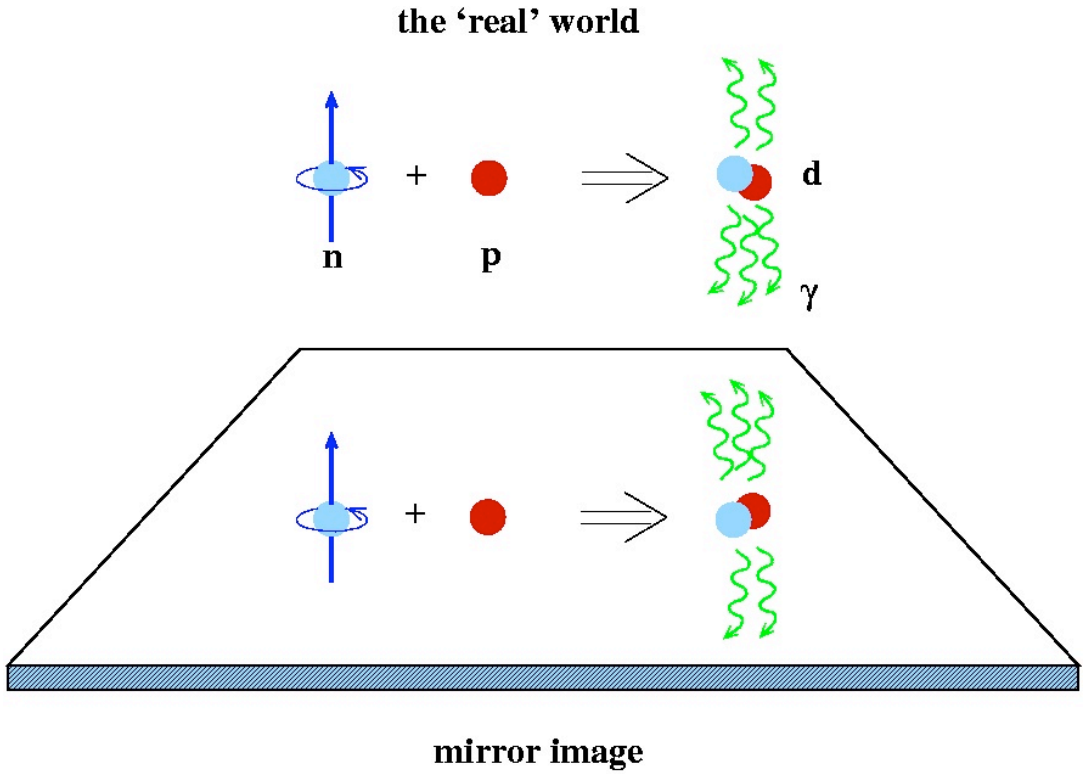
$\vec{n} + p \rightarrow d + \gamma$ at LANSCE

NPDGamma will measure A_γ, the parity-violating asymmetry in the distribution of gamma-rays emitted in capture of polarized cold *n* by para-H_2

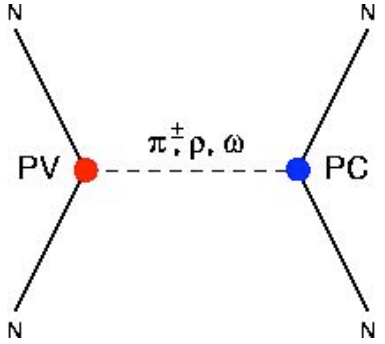
If the up/down γ rates differ, parity is violated

Expected asymmetry: ~ - 5 x 10^{-8}

Goal experimental error: 0.5 x10^{-8}



The Hadronic Weak Interaction

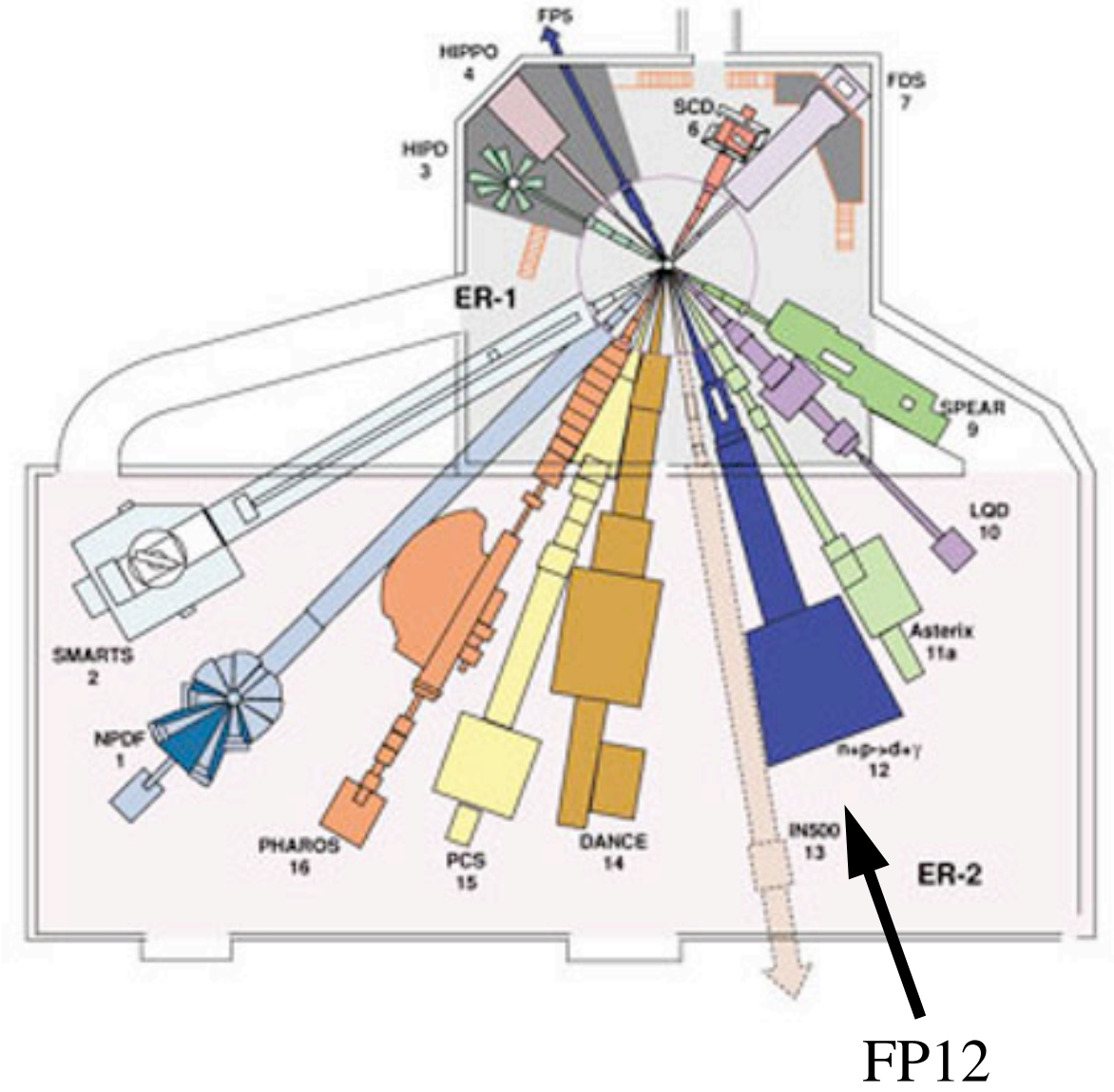


$$A_{\gamma} = \frac{1}{P_n}\frac{N_u - N_d}{N_u + N_d}(-0.11 f_{\pi})(5 \times 10^{-8})$$

- The pion is the lightest and longest range meson.
- The pion coupling is generated by weak neutral currents.
- $\vec{n} + p \rightarrow d + \gamma$ isolates f_{π}. Negligible contributions from other mesons.
- No uncertainty from nuclear wave functions. Strong two-body solvable with small (5 %) uncertainties.
- Previous determinations of f_{π} disagree. (Units of 10^{-7})
  - DDH reasonable theoretical range 0 - 11.4, best value 4.5
  - ^{18}F experiment gives 0 ± 3
  - ^{133}Cs anapole moment gives 10 ± 4
  - PV in compound nuclei gives 12 ± 2
- Goal: Measure f_{π} with a statistical uncertainty of 0.5 (10% of expected size) and negligible systematic uncertainty.

LANSCE at Los Alamos NATIONAL LABORATORY

LANSCE FP12



FP12 was built by the NPDGamma experiment.

FP12 provides the largest pulsed cold neutron flux in the world.

~6×10^8 cold neutrons per 20 Hz pulse out of the end of the 20 m supermirror guide.

NPDGamma Setup on FP12

20 Hz pulsed neutron beam

FP12 views a cold hydrogen moderator in backscattering geometry

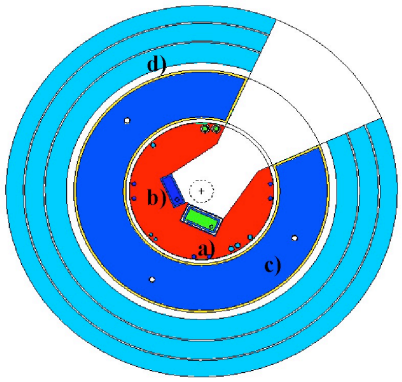
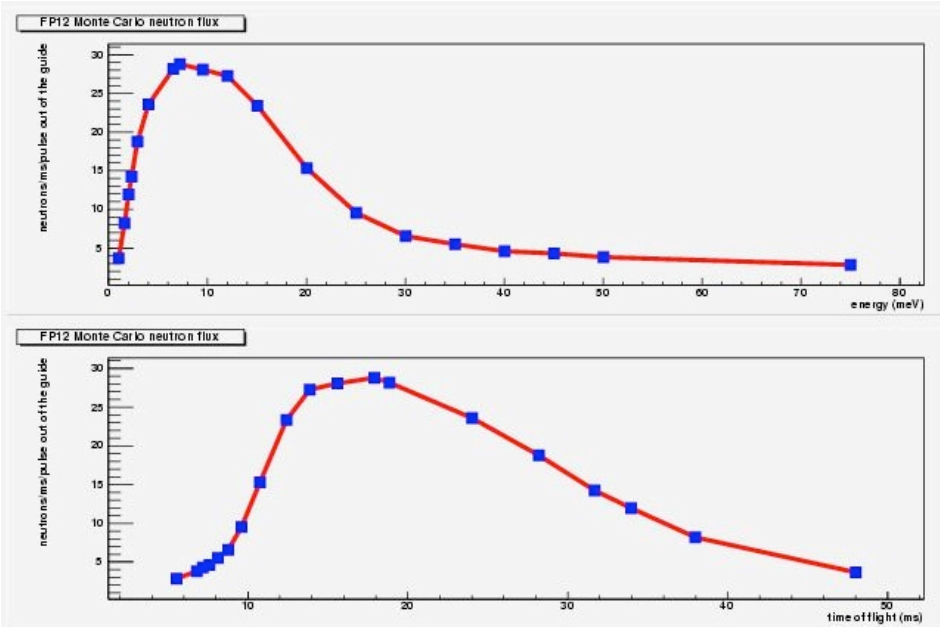


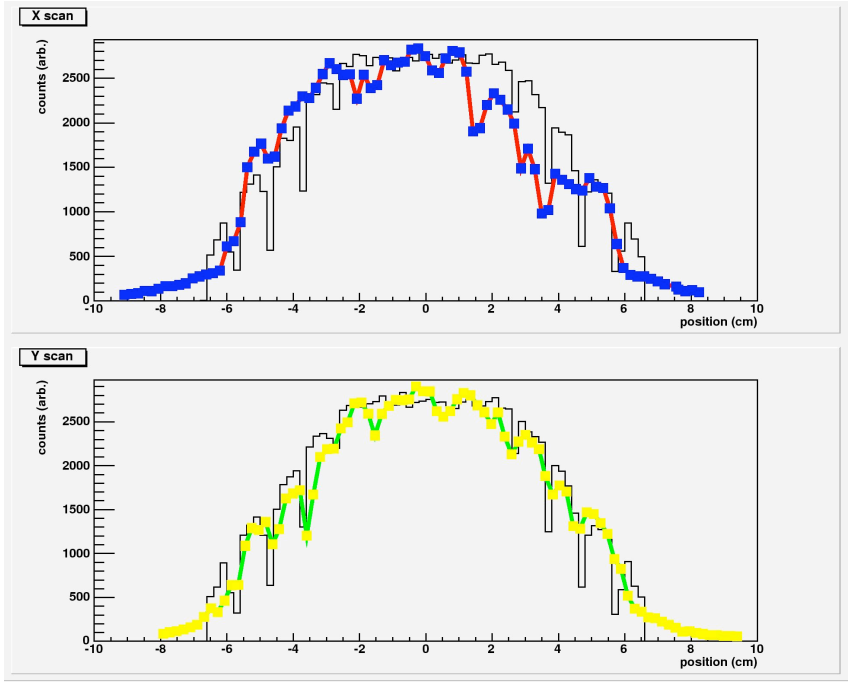
Figure 1. The scheme of the liquid H_2 coupled moderator layout at LANSCE: a) liquid H_2 coupled moderator; b) H_2O partially coupled moderator; c) Be-reflector, d) Pb-reflector

Measured and Monte Carlo neutron flux at the end of the ~20 m neutron guide.
(MC based on moderator brightness measurements made in January 2003.)
Verify total flux during experiment with ^{3}He ion chamber beam monitors.

MC energy and tof spectrum (x10^6)



tightly collimated
guide scan data vs. MC



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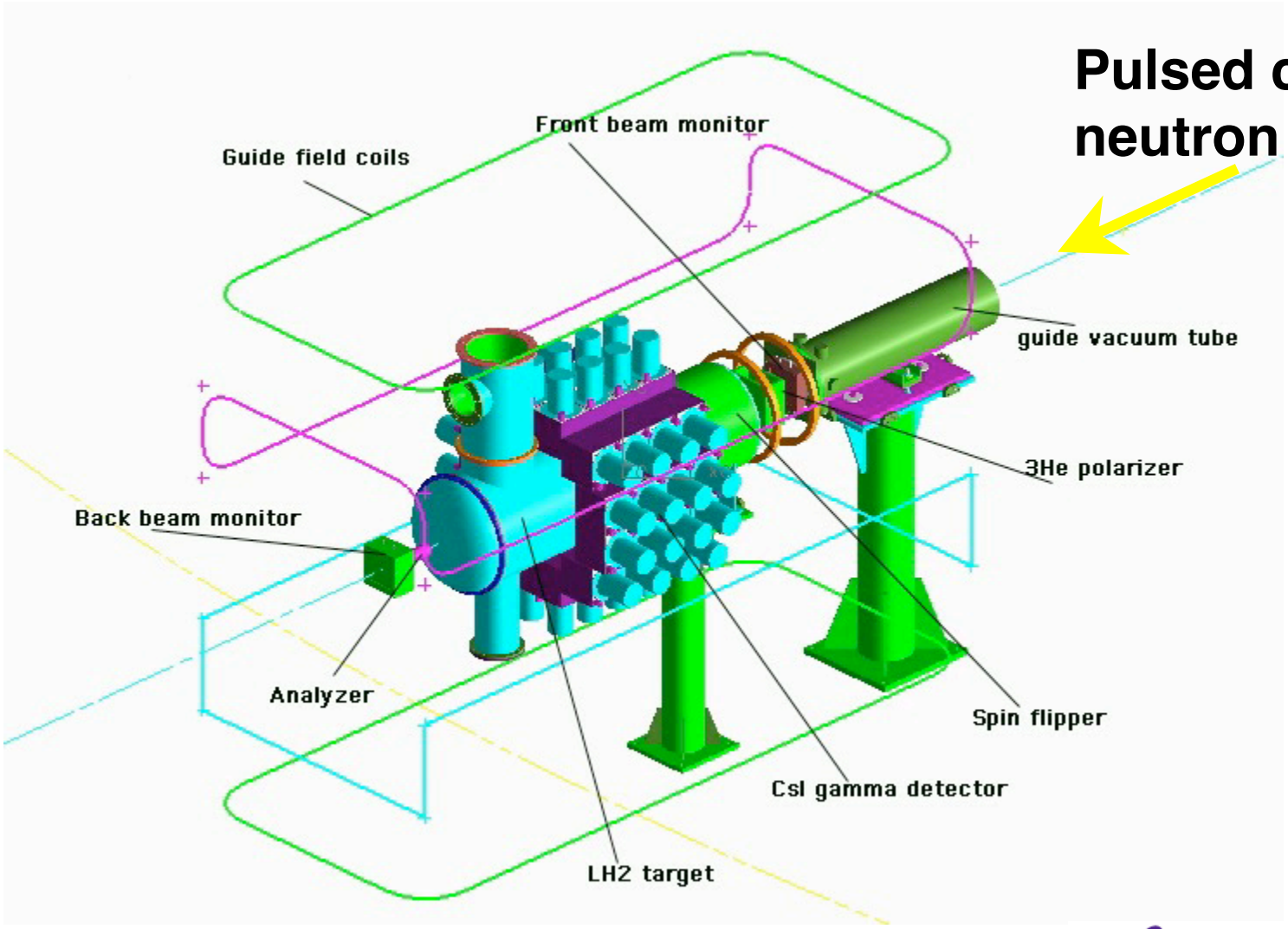
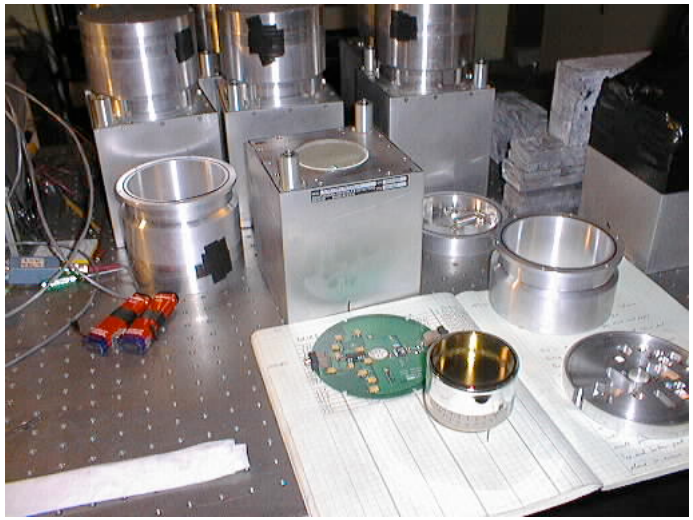
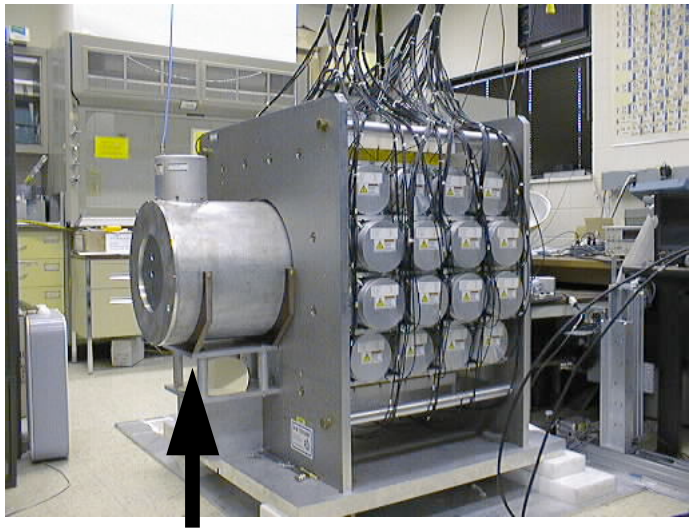
Drawing of NPDGamma Apparatus





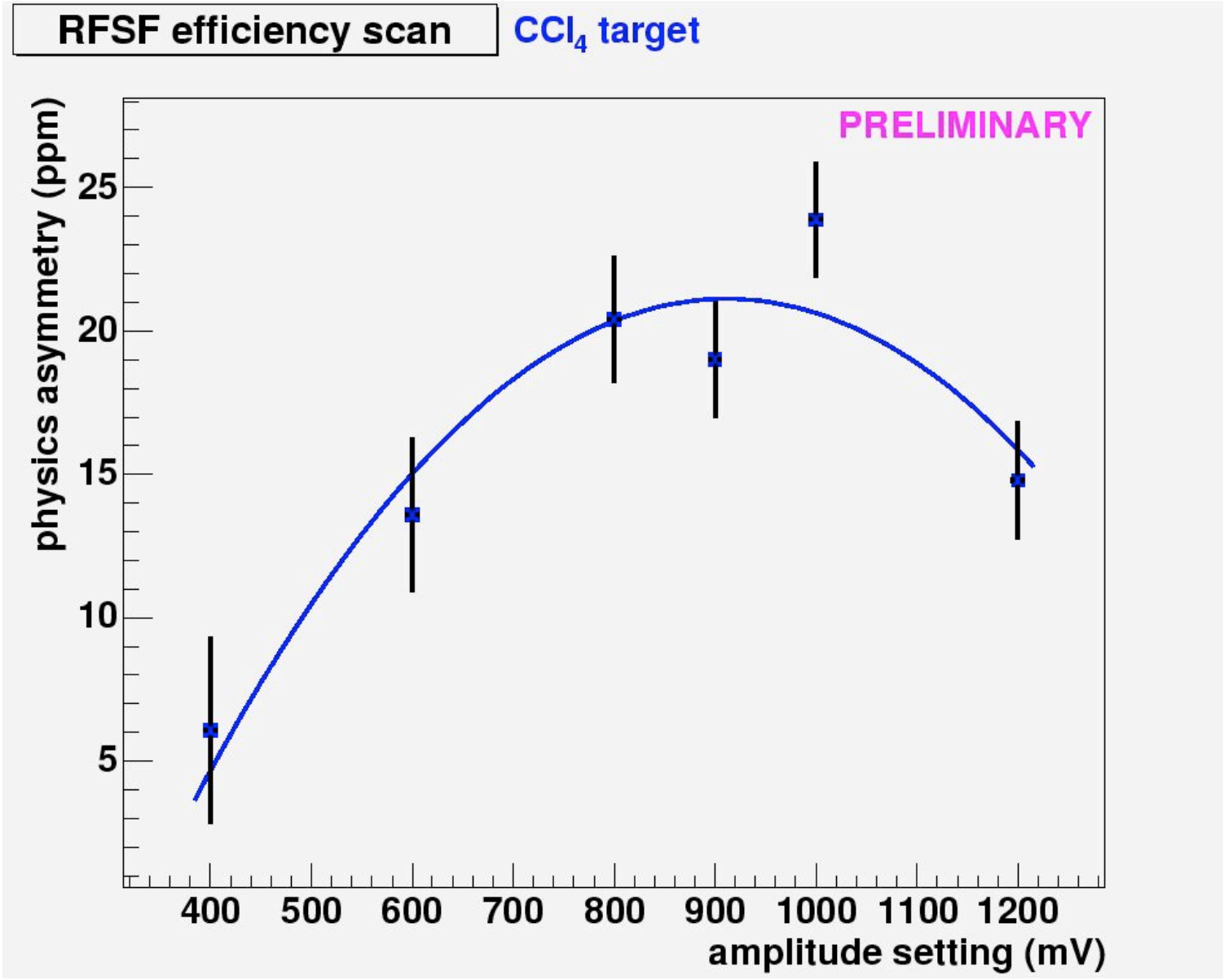
CsI & photodiodes



spin flipper

Chlorine Asymmetry

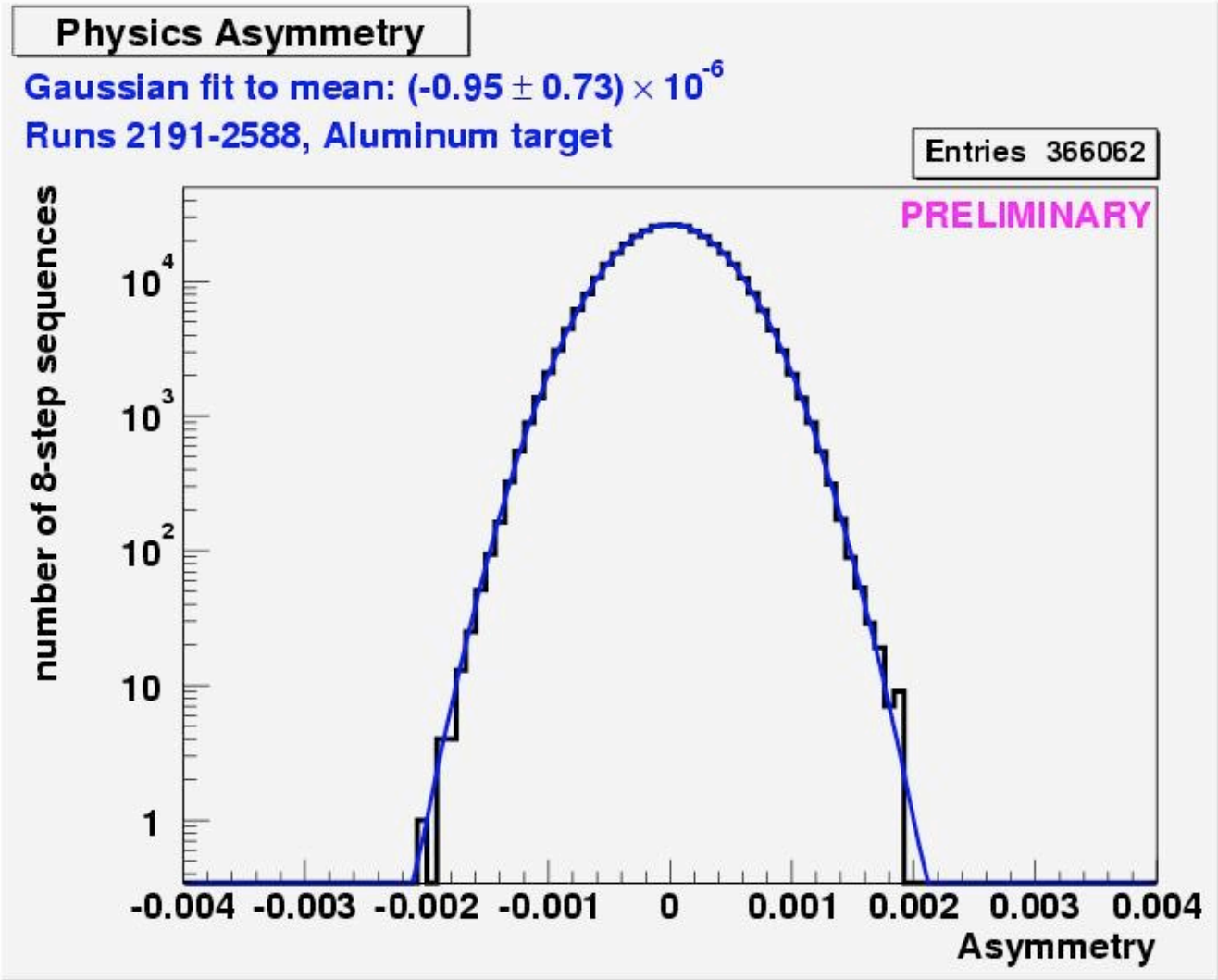
use the known ^{35}Cl PV asymmetry (~20 ppm) as a check of the apparatus



- four hours of data per amplitude setting

- Varying the spin flipper amplitude +/- from optimum reduces spin flip efficiency and therefore the expt'l asymmetry

Limit on PV asymmetry from polarized n capture on Al



Low noise detector system operating at counting statistics --> data are Gaussian to four orders of magnitude

No observed asymmetry --> no problem with background signal in the experiment

$$\vec{n} + p \rightarrow d + \gamma$$

Status

- Experiment commissioning run completed February-April 2004
  - beam line
  - polarizer
  - spin flipper
  - beam monitors
  - detector array
  - DAQ
- Completed and commissioned FP12, the highest flux pulsed cold neutron flight path in the world.
- Measured (set limits on) parity violation from polarized cold neutron capture in several materials (Al, Cu, In, B, Li) -- important since they are present in the apparatus and contribute to background.

Schedule

- Install hydrogen target Summer 2004.
- First production data in 2005, 1000 hrs--> A_γ to $\pm 5 \times 10^{-8}$.

  (This will be a factor of two improvement on previous A_γ measurements.)